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Lin CORPORATION

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June 9, 1995

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street N.W.
Washington, DC 20554

Re: CC Docket No. 92-297, RM-7872, RM 7722
Ex Parte Presentation

Dear Mr. Caton:

Enclosed for filing with the Commission in this docket are five copies of a report prepared by LinCom Corporation entitled, "Evaluation of Bellcore's Interference Analyses for Co-Frequency Sharing of the 28 GHz Band by the Local Multipoint Distribution Service (LMDS) and the Fixed Satellite Service (FSS)." This report was prepared under contract to Teledesic Corporation.

The enclosed LinCom report demonstrates that the April 1995 Bellcore report entitled, "Interference Analyses for Co-Frequency Sharing of the 28 GHz Band by the Local Multipoint Distribution Service (LMDS) and the Fixed Satellite Service (FSS)", is flawed with numerous technically misleading, inaccurate and invalid assumptions and results. Consequently, Bellcore's report should not be used as a basis for establishing rules of operation for LMDS and FSS.

Copies of this letter and the enclosed LinCom report are being provided simultaneously to those individuals identified below.

Respectfully submitted by:

by: Wm C Lindsey
Dr. William C. Lindsey, Chairman of the Board
LinCom Corporation

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List ABCDE

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Evaluation of Bellcore's Interference Analyses for Co-Frequency Sharing of the 28 GHz Band by the Local Multipoint Distribution Service (LMDS) and the Fixed Satellite Service (FSS)

Prepared by:

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June 9, 1995

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TR-95042

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1.0 Introduction and Summary

In 1994, the Federal Communications Commission (FCC) formed an advisory group known as the "LMDS/FSS 28 GHz Band Negotiated Rule Making Committee" or NRMC. The purpose of this committee was to provide the FCC with recommendations that could be used in the formulation of policy with regard to co-frequency sharing of the 28 GHz band by the LMDS and FSS. The NRMC Working Group 1 considered all proposed solutions presented to it by the participants; however, none were deemed feasible by any combination of LMDS and FSS proponents.

In April of 1995, Bellcore presented a paper titled "Interference Analyses for Co-Frequency Sharing of the 28 Band by the LMDS and FSS". In this paper, Bellcore asserts that it is possible to share the 28 GHz band between the LMDS and the FSS with 99.9% availability for both systems, provided that three major steps are taken. These include: (1) increasing the LMDS hub transmitting power along with the use of an improved subscriber antenna pattern, (2) reducing the minimum required signal to interference power ratio from 26 dB to a value between 8 and 13 dB, and (3) implementing an LMDS/FSS spectrum protocol to reduce the number of interference events.

The purpose of this report is to investigate the feasibility of sharing the 28 GHz band using the three Bellcore assertions listed above and to verify the results presented in the Bellcore report. Bellcore claimed that in computing the minimum required separation distances and the LMDS system wide availability, the interference level was based upon the peak interference spectral density rather than the peak interference power in the receiver bandwidth. Using that assumption, this report shows that there is an average interference probability of 0.286% that T1 rate Teledesic Standard Terminals (TSTs) will interfere with the reception of CellularVision subscribers. This average interference probability will increase to a whopping 20.1% when the interference is coming from 1440 basic rate (16 kbps) TSTs in a 53.3 km on a side Teledesic cell. This report will demonstrate clearly that Bellcore has used the peak interference power in their calculations in spite of their statement that the peak interference power spectral density was used.

From the service provider point of view, it is extremely important to note that the average interference probability is not a good measure of sharing the band since this probability is diluted by the large rural areas where there is little usage of the FSS uplinks. If the LMDS and FSS services are to be deployed based on this average interference probability, then it is very likely that urban area LMDS subscribers will experience an unacceptable interference while those subscribers in the mountain or desert areas will experience negligible interference.

Bellcore introduced a so called " Spectrum Protocol " which is a rather complex and costly set of operating restrictions placed upon the FSS providers. Bellcore claimed that by implementing this protocol, some cases of harmful interference into the LMDS subscribers can be avoided. In this protocol, the burden is on the FSS provider to match its channel assignments to the channel gaps and a set of preferred frequencies for each LMDS within the FSS service area.

The procedure described by Bellcore is rather flawed because it ignores several facts. The channel gaps between the video channels will be used for the return links from LMDS subscribers to hubs, which incidentally, were not addressed in the Bellcore analysis of the LMDS system wide availability. Bellcore also ignored the fact that there may be several LMDS service providers within the FSS service area, each with different channel assignments, gap frequencies, and preferred frequency lists. Bellcore puts the burden on the FSS service providers to keep track of complex details such as, the knowledge of the precise boundaries of all LMDS service providers cells within its service area, the applicable protocol for each cell, the ordered list of the preferred frequencies in each cell and the precise location of the FSS terminals within the LMDS cell. This requires a high technical complexity, enormous administrative burden, and increased cost. Even more importantly, it results in an inefficient use of the spectrum and reduced FSS system capacity. Furthermore, Bellcore admits that this procedure can only be used in few special cases, and in some cases (especially when the FSS uplinks are clustered) no improvement in the LMDS system wide availability results by using this protocol.

The results presented in this report confirm the conclusion reached by the NRMC Working Group 1[1], namely, that sharing of the 28 GHz Band by the LMDS and the FSS is not feasible. This report also shows that the Bellcore report contains technically misleading, inaccurate statements and assumptions, and that contrary to their claim of using conservative assumptions, their approach is rather radical and should not be used as a basis for establishing rules for the LMDS and FSS operation in the 28 GHz Band.

[1] Report of the LMDS/FSS 28 GHz Band Negotiated Rule Making Committee, 23 September 1994.

2.0 Review of the Previous NRMC Reports

The Federal Communications Commission established a negotiated rule making committee to determine the feasibility of co-frequency sharing between LMDS and FSS in the 27.5-29.5 GHz band. Working Group 1 was created to study the effect of the interference from the FSS uplinks into the LMDS subscribers and hubs. This group concluded after extensive analysis and simulations, that a technical solution based on the system characteristics and methodologies considered, can not be found and the co-sharing possibility was deemed unfeasible. The problem, in large part, is due to the proposed wide spread distribution of both FSS earth stations and LMDS receivers throughout the same geographical area and the desire to impose minimal restrictions on the siting and operation of both systems. Several mitigation techniques were proposed to eliminate or reduce interference; however, none of them were found to be effective.

The analysis presented in the NRMC final report for the LMDS system availability was based on the peak interference power into the desired receiver bandwidth. In performing the analysis, the goal was to determine the area within an LMDS cell in which an FSS uplink can operate without causing the C/(N+I) at any LMDS subscriber within the cell to fall below the minimum acceptable value of 26 dB for clear weather conditions and 13 dB for rainy weather conditions.

A sample of the results presented in the NRMC final report is given in Table 2-1 below. The case considered is that of a single T1 rate FSS user in an LMDS cell. Both the hub-to-subscriber and subscriber-to-hub links were considered in clear and rainy weather conditions. A three mile (4.8 km) radius LMDS cell was considered

Table 2-1. Minimum Protection Distances and Cell Availability

Hub-to-Subscriber Link	**Clear Weather**	**Rainy Weather**
Boresight min. Clearance	23.7 miles (38.1 km)	8.0 miles (12.9 km)
Sidelobe (45°) min. Clearance	1.5 miles (2.4 km)	2.88 miles (4.6 km)
Backlobe min. Clearance	0.075 miles (0.12 km)	0.494 miles (0.8 km)
Cell Availability (% of cell)	79.7%	57.7%
Subscriber-to-Hub Link	**Clear Weather**	**Rainy Weather**
Boresight min. Clearance	0.504 miles (0.81 km)	3.62 miles (5.8 km)
Sidelobe (45°) min. Clearance	0.504 miles (0.81 km)	3.62 miles (5.8 km)
Backlobe min. Clearance	0.504 miles (0.81 km)	3.62 miles (5.8 km)
Cell Availability (% of cell)	97.2%	0.0%

3.0 Review of the Bellcore Report

In response to the final findings of Working Group 1 of the NRMC summarized in the previous section, Bellcore was contracted by CellularVision to propose ways to facilitate the sharing of the 27.5 - 29.5 GHz band between the LMDS and the FSS. In the report, Bellcore proposed three "major steps" that have been taken to achieve a 99.9% LMDS system availability. These steps are summarized below :

a) Increase the LMDS hub transmitted power by 3.8 dBW, with no power control and use an improved LMDS subscriber antenna sidelobe mask,

b) Reduce the minimum required C/(N+I) criteria from 26 dB to the range of 8-13 dB, and

c) Use the Spectrum Protocol to coordinate the narrowband FSS traffic access such as to reduce the interference exposures to LMDS subscriber.

In calculating the minimum protection distances and the LMDS system wide availability, Bellcore calculated the interference based on the peak power spectral density. In Section 4 of this report, it will be shown that the above Bellcore assertion is not valid.

Bellcore showed that it is possible to achieve a 99.9% LMDS cell availability in the presence of fifteen T1 rate FSS users, by increasing the hub transmitting power, implementing an improved subscriber antenna mask and allowing a slightly degraded picture quality at a C/(N+I) of 11 dB. At C/(N+I) of 13 dB, Bellcore found the availability of CellularVision LMDS cell to be 99.8%. Bellcore also found that in the presence of 1440 basic rate (16 kbps) FSS users, the availability of the LMDS cell is 99.65% at C/(N+I) equal to 13 dB.

Bellcore also demonstrated that by using the FSS/LMDS spectrum protocol, the number of harmful co-frequency interference exposures between the FSS uplinks and the LMDS subscribers can be limited; hence, availability can be increased to more than 99.9%.

Bellcore furthermore asserted that their analysis was based on conservative assumptions and that the availability of actual LMDS systems will be greater than the computed values. Bellcore estimated the cumulative improvement in the availability to range from 60 to 90%. This assertion is refuted in Section 4 of this report.

4.0 Flaws in Bellcore Report

This section addresses some of the assertions made by Bellcore in their report.

4.1 Video Quality

Using the modified parameters In Table 1.1 of the Bellcore report, it was shown that the C/N at the edge of coverage in clear sky conditions is 31.7 dB. Throughout the report, Bellcore stated that a C/(N+I) in the range of 8-13 dB represents an acceptable level for the LMDS subscriber. That means that an LMDS subscriber located in an area where an FSS uplink is present must endure frequent fluctuations in the picture quality from 31.7 dB all the way down to 8 dB when ever the FSS uplink is active, which is almost a 24 dB variation. This frequent, and unpredictable degradation is extremely annoying to the unexpecting LMDS subscriber.

Even if we assumed that this fluctuation in video quality is not annoying, the assertion that a C/(N+I) of 8 to 13 dB is acceptable to an LMDS subscriber is highly subjective. Bellcore's claim that these levels will result in picture quality comparable to that delivered by current cable systems is perplexing since an 8 dB C/(N+I) is barely above the FM threshold, where the performance of the system will almost be noise dominated.

4.2 Cell Size

Bellcore assumed that there are 64 LMDS cells (8 km $\times$ 8 km with 5 km radius from center to corner) in a Teledesic cell. This is not a valid assumption. The Teledesic cell is a 53.3 km on a side which, on the average, results in roughly 39 LMDS cells within a Teledesic cell. If higher density for the LMDS cells is assumed, the chance of several FSS uplinks being clustered in an LMDS cell will decrease and on the average the calculation will show higher availability rates.

Moreover, if it assumed that the size of LMDS cells is decreased such that 64 LMDS cells fit within one Teledesic cell, then that would result in decreasing the number of subscribers in a given LMDS cell along with an increase in the cost since 64 hubs are required instead of 39. The irony in this is that CellularVision has repeatedly argued against the idea of using smaller cells.

4.3 LMDS System Availability

The approach that Bellcore used in their analysis for determining the LMDS system availability and the assumptions they made were not reasonable. First, it was assumed that the demand of T1 rate TSTs is the same everywhere, i.e. Bellcore assumed that the T1 rate users are uniformly distributed. Then, they used the "binomial distribution" to model the number of active FSS uplinks in a given LMDS cell. Their system-wide availability was then calculated as a weighted average of the availability of all cells. This approach of using uniform weighting is not realistic because it neglects the fact that the FSS uplinks are not uniformly distributed in all areas. In rural areas, there would be lower usage of T1 terminals, while, in urban and metropolitan areas, the probability of clustered T1 rate TSTs would be high. It is obviously biased to include those LMDS cells, with availability of 100% (i.e. no active FSS uplink) in the averaging process to calculate the system-wide availability.

Even if we assume that Bellcore's approach is valid, the required system-wide availability of 99.9% was not achieved at C/(N+I) of 13 dB for both CellularVision and TI LMDS systems with the modified system parameters (shown in Figures 3.4 and 3.5 of the Bellcore report, respectively). In both cases, an availability of 99.83% is shown. If we use 39 LMDS cells rather than 64 LMDS cells, the availability will be even lower.

Moreover, in their calculation of the cell availability, Bellcore considered the interference effects from only those T1 users that are located within the LMDS cell boundary. In the NRMC analysis, it was clearly demonstrated that the interference effects of an active T1 rate user may extend beyond the boundary of the LMDS cell where that active is located. The same comments made above can be applied as well in the presence of 16 kbps basic rate users.

An assertion made by Bellcore in their report is that their calculation of the LMDS availability was based on the peak interference power spectral density rather than the total interference power into the receiver bandwidth. This is not a valid assertion because if that is the case then the interference from a 16 kbps basic user will be the same as that is from a T1 rate user, and hence the LMDS availability in the presence of 1440 basic rate users should be much worse than the availability of the LMDS cell in the presence of 15 T1 users. In Figure 3.8 of the Bellcore report, Bellcore calculated the LMDS system availability in the presence of 1440 basic rate users at 13 dB C/(N+I) to be 99.65% compared to 99.8% availability in the presence of 15 T1 rate users. These calculations must have been done using the total interference power rather than the interference power spectral density. Hence, their assertion that the computed system-wide LMDS availability is based on a conservative assumption such that an actual improvement of up to 50% (see Table 3-2 of the Bellcore report) is possible is not a valid statement.

4.4 Claims of Conservative assumptions Used in Computing Availability

In addition to the claim made by Bellcore regarding the use of interference power spectral density instead of the total interference power in their calculation of the system availability, Bellcore claims other conservative assumptions were used in their report. These claims are discussed below :

a) Free Space Propagation :
Bellcore report claims that blockage due to buildings and/or foliage will block some LMDS receivers from some FSS uplinks. That might be true but unfortunately there

will be other LMDS links where the reverse condition will occur and in those cases the degradation of the LMDS link performance will be exacerbated by the difference in foliage attenuation over the desired and interference paths. For the majority of the desired and interference paths, attenuation of blocking and/or foliage will probably be nearly the same on both paths and hence the C/(N+I) will be degraded due to the attenuation of the desired signal. There will be very few opportunities to deliberately locate LMDS receivers to take advantage of buildings or foliage blockage to mitigate interference.

b) Rain Rate Statistics :
Bellcore's calculations were carried out by applying the rain rate corresponding to 0.1% of the time to the statistics for 1% of the time. They claim that the actual availability will be improved by 20-30% compared to that calculated. It is found that there is no substantiated evidence to such a statement. As a matter of fact, it is shown in Section 5 of this report that the result computed by applying actual probability weightings is almost the same as what is computed by the method Bellcore used.

c) LMDS Antenna & FSS Uplink Antenna Masks :
Bellcore claims that the LMDS & FSS antenna masks were used in the calculation of system availability and that an improvement of up to 25% in system availability is possible if the nulls of the LMDS subscriber antenna can be strategically pointed in the direction of the FSS uplink and the nulls of the FSS uplink antenna are pointed in the direction of the LMDS subscriber antenna. It is found that there is no basis for such a claim. The ITU-R reference antenna pattern mask is used because there are sidelobe peaks that may exceed the mask which will negate the advantages of the nulls.

Moreover, Bellcore has already used a revised antenna mask for the LMDS subscriber with a much better sidelobe performance than that recommended by the ITU-R without providing justification that such antennas can be manufactured and maintained.

d) Satellite Capacity:
Bellcore states in their report that all their calculations were carried out assuming that the Teledesic satellite is operating at full capacity with 15 simultaneous T1 uplinks, yet they claim that the average loading is only 9 T1 uplinks for 2% blocking during the peak busy hour. This statement is not justified and an argument can be made that, based on the ERLANG B formula, the case of 1440 basic rate users, and for an availability of 99.9%, the offered load will be 1359 ERLANGs, resulting in 1359/1440 = 94% utilization[2]. In any case, Teledesic intends to utilize an elaborate channel packing scheme such that its uplink capacity of 396 MHz is used as efficiently as possible at all times. There is no justification for Bellcore's claim that up

[2] J. Bellamy, Digital Telephony, Wiley, 1991. pages 472-473.

to 50% improvement in the LMDS availability is achievable due to the fact that the FSS system will not operate at full capacity. Besides, it is unlikely that FSS providers are going to limit their service capacity to reduce the interference toward LMDS subscribers when satellites are deployed.

e) Full Spectrum Availability :
   Bellcore report states "For a video distribution LMDS system, the busy hours for the FSS and LMDS systems are different". Again, this assertion is not justified. The Teledesic system is planning to provide a variety of services including voice, data, video, and images for both business and residential applications. The resulting traffic is better modeled as uniformly distributed for all hours of the day. It should not be expected that an increase of availability comes from this assumption.

4.5 Back Channel (Subscriber-to-Hub) Consideration

Bellcore's report ignores the subscriber-to-hub channel availability in contrast to the conclusion reached by the NRMC final report that the interference caused by the FSS users present a major problem in the sharing efforts. A simple analysis can demonstrate that in order for the subscriber-to-hub link to be unencumbered, the FSS uplink cannot be located in that LMDS cell.

4.6 Bellcore Spectrum Protocol

Bellcore claims to have developed a "Spectrum Protocol" algorithm that will improve the LMDS availability. In effect, Bellcore suggests that the LMDS service provider tailers the implementation of this protocol to most efficiently meet the LMDS system performance objectives, and asks the FSS service provider to comply with the protocol.

In addition to the added burden in implementing such a protocol and the resulting extra costs, there are many points that can be raised against such a procedure. Some of these points are summarized below:

a) In all of their previous papers, CellularVision has argued that LMDS it is a two-way service with subscriber-to-hub traffic occupying the gap bands between the video channels. Now Bellcore is proposing a spectrum protocol that asks the low-rate TST users to use the gap bands for their traffic (In essence their "novel" spectrum protocol is even worse than band segmentation, because it is based on time-sharing). Note that the back channel was ignored throughout Bellcore's analysis.

b) Bellcore's spectrum protocol allows for a specific channel in each LMDS cell to be used "sequentially" by FSS users. Since each video channel occupies a bandwidth of 18 MHz, then at most one T1 TST user could be using that channel (and even then it would cause partial band interference on another channel). Another point to consider is that based on the modified CellularVision link budget used by Bellcore, a single T1 user located in a specific LMDS cell will interfere with up to 4 adjacent cells. Therefore a specific video channel assigned to a T1 TST in a single LMDS cell may not be used by other T1 TST users in adjacent cells.

c) Bellcore states that the spectrum protocol improves the system availability to greater than 99.9% however, they do not include the assigned channel to the FSS service in their calculation. Their justification, was that the LMDS service provider can decide whether or not to offer program material in this channel. This abandoned channel idea is actually a form of band segmentation. In another part of their report, Bellcore states that the spectrum protocol is useless for the TGT case and for the case when more than 1 T1 TST is operating.

d) Bellcore states that "The FSS uplink continues to search the list until a frequency is found that is not currently in use by other up-links accessing the satellite receiver". The delay encountered in this process, if ever successful in getting through, is expected to be high.

e) Bellcore states that "The LMDS system uses the entire frequency band in each cell, with reduced availability in a single channel". They then claim that "the full allocated bandwidth is available everywhere for uplink transmission even if all transmissions are in the same LMDS cell". If all T1 rate transmissions are in the same LMDS, wouldn't that force more than one LMDS channel to accept reduced availability?

f) Based on Bellcore's spectrum protocol, 190 frequency slots are available for basic rate users ($7 \times 19 + 57$) before causing harmful interference to channels other than the single reduced availability channel. That is only 13% of the total number of basic users that could be located in a single LMDS cell.

g) In their discussion of the use of spectrum protocol for digital, multiple access LMDS systems, the Bellcore report states "... an FSS uplink would traverse the list of ordered frequencies specified by the LMDS service provider ...". Since this is a multiple access media type, then, as the number of LMDS subscribers increases, chances are there would be no frequencies left in this list to choose from. Moreover, as Bellcore rightfully states there are no frequency gaps in the digital LMDS systems.

h) Bellcore rightfully states that by using the spectrum protocol, the capacity of the return links will be reduced. They suggest that some portion of the allocated LMDS bandwidth outside the portion shared with FSS could be reserved for return link traffic. This statement is not valid for two reasons. First, even though the Teledesic system overlaps 400 MHz of the 1 GHz LMDS bandwidth, that does not mean that future FSS systems will not share the remaining spectrum with LMDS. Second, if the return link capacity can be traded for downlink availability, it would result in a decrease in the number of video channels that can be transmitted on the downlink and hence severely affecting the competition with cable services.

i) Bellcore admits that harmful interference will occur repeatedly at LMDS subscribers deployed near FSS uplinks. They suggest some mitigation techniques, which if implemented, would result in an increase in both the LMDS system and the FSS system costs and complexities, and a reduction in system performance (increased access delay for FSS users).

j) Bellcore neglects the fact that within a Teledesic cell there may be many LMDS service providers, each with different channel assignments, gap frequencies and preferred frequency lists. This makes the efficient assignment of channels within the FSS cell impossible and greatly complicates the satellite hardware and channel assignment software. In addition, the protocol implies that just to assign a channel, the FSS system needs to know the precise boundaries of all LMDS service provider cells within it's service area along with the applicable protocol for each cell and the ordered list of preferred frequencies for each cell. This represents an unreasonable burden in terms of the associated complexity, memory requirements, real time processing and data administration requirements.

5.0 Simulation Results

A computer simulation was performed to test the validity of the results given in the Bellcore report. In this simulation, the CellularVision hub transmitting power is increased to that proposed by Bellcore. The required C/(N+I) values in both clear sky and heavy rain conditions are reduced to 13 dB. The ITU antenna pattern is used to model the Teledesic Standard Terminal (TST), see Figure 5-1. We cannot verify the availability of the improved LMDS subscriber antenna pattern proposed by Bellcore at the present time. The original pattern given by Suite 12 in the NRMC report is used to model the CellularVision subscriber terminal, see Figure 5-2. The simulation is setup to model a Teledesic cell 53.3 km on a side. An LMDS cell of 3 mile radius is placed at the center of the Teledesic cell. CellularVision subscriber terminals are randomly placed throughout the LMDS cell and the C/(N+I) values are calculated.

The percentage of the LMDS cell area with C/(N+I)<13 dB is then computed by randomly placing fifteen T1 TSTs in the Teledesic cell. The average percentage of area with C/I<13 dB is summarized in Table 5-1. This average percentage of area can also be interpreted as the interference probability. Using the method proposed by Bellcore, the interference probabilities obtained in cases of clear sky and heavy rain conditions are combined and the average interference probability is found to be 0.286%. For the case of 1440 basic rate TSTs, and by using the same assumption used by Bellcore in their report in regard to the interference power density being flat over the desired signal bandwidth, the average interference probability is found to be 20.07%.

In order to verify the method of computing the average interference probability, the interference probability is then computed for different rain rates. Weighted by the probability of occurrence, the interference probabilities for different rain rates are summed up and the average interference probability is found to be 0.65% as shown in Table 5-2. This result is in a close agreement with the Bellcore result of 0.69% which was obtained by assuming 99% clear sky and 1% heavy rain conditions.

The areas expected to experience significant interference in an LMDS cell are plotted in Figures 5-3 through 5-6. The interfering TST is placed at two different locations inside the LMDS cell namely, at 2.1 miles and at 0.75 miles from the cell center. Figures 5-3 and 5-4 represent clear sky conditions and Figures 5-5 and 5-6 represent the heavy rain condition. To get a real feeling about the size of the interference area and hence an appreciation of the severity of the interference, the contours obtained in Figures 5-3 and 5-4 are plotted on top of Los Angeles, California and Washington, D.C. city maps. Figures 5-7 and 5-8 correspond to Figure 5-3 and 5-4 respectively, for Los Angeles. Figures 5-9 and 5-10 correspond to Figure 5-3 and 5-4 respectively, for Washington DC. Due to the large size of interference areas, the contours for the heavy rain cases have not been illustrated on the city maps.

Bellcore did not analyze the effects of the interference from the FSS uplinks into the subscriber-to-hub return channels despite the fact that the NRMC report concluded that the interference on these channels is rather significant. Analysis and simulation were carried out in this report and the results regarding the areas, within which, all LMDS subscribers return channels to the hub are expected to experience significant interference are depicted in Figures 5-11 through 5-14.

Figure 5-11 shows that whether the TST is located at 2.1 miles or 0.75 miles from the LMDS cell center, there would be no area within the boundary of the LMDS cell at which the return channel will experience interference levels such that C/(N+I) falls below 13 dB in clear weather condition. However, Figure 5-12, clearly shows, that if the TST is placed at 0.3 miles from the center of the cell, then there would be some areas within the LMDS cell boundary that would experience severe interference. In fact, return channels from all subscribers located at the edge of the cell will be rendered ineffective. This is a rather serious situation especially considering the fact that in heavily populated urban areas, chances are that FSS uplinks will be closely clustered around the LMDS hub.

Figures 5-13 and 5-14 show that the situation is even worse in the rainy weather condition. It is worth noting that by comparing Figures 5-13 and 5-14 with Figures 5-5 and 5-6, it is clear that the degradation in the subscriber-to-hub return channels is even worse than the degradation in the hub-to-subscriber forward channels. In fact, Figures 5-13 and 5-14 clearly demonstrate that the return channel from any subscriber located any where at the edge of the LMDS cell will be rendered ineffective under heavy rain conditions.

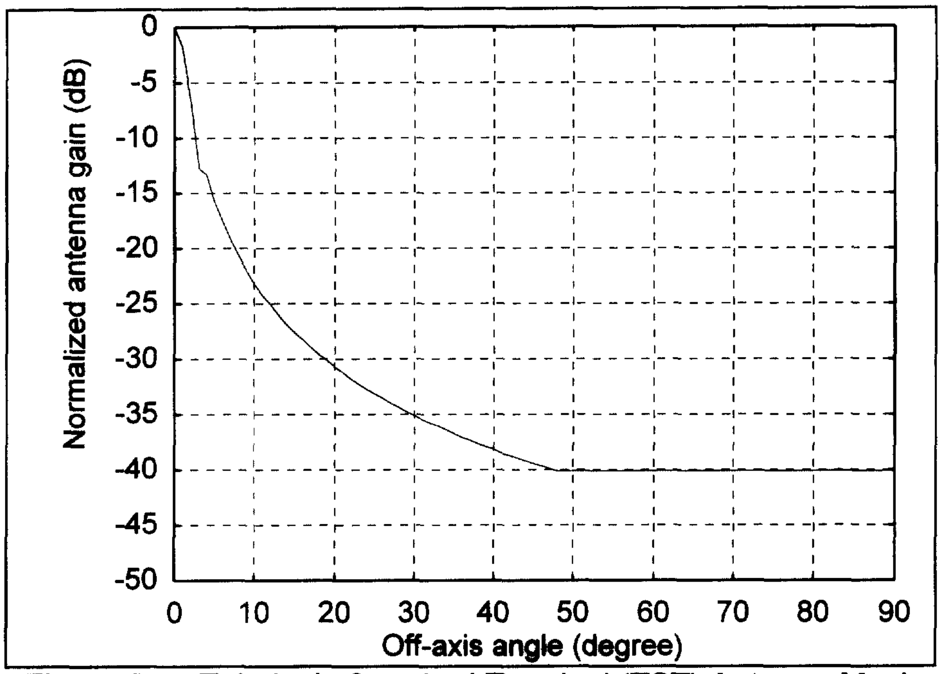

Figure 5-1. Teledesic Standard Terminal (TST) Antenna Mask

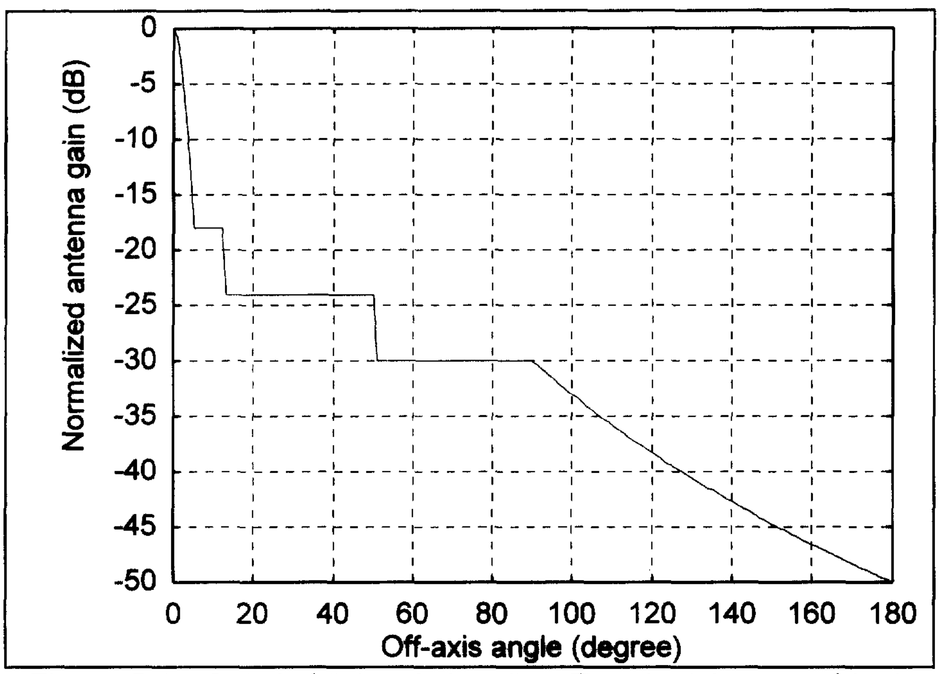

Figure 5-2. CellularVision Subscriber Terminal Antenna Mask

Table 5-1. Interference Probabilities

	15 TSTs in a Teledesic cell	1440 TSTs in a Teledesic cell	1 TST in an LMDS cell
clear sky	0.236%	19.36%	0.562%
rain	5.25%	90.42%	13.27%
average given by 0.01*rain+0.99*clear sky	0.286%	20.07%	0.69%

Table 5-2. Average Interference Probability Using Rain Attenuation Model

% time	Power up(dB)	prob	Δ prob	% of area w/ C/I<13dB	
0.01	17.1	0.0001	0.0001	61.68	0.006168
0.02	17.1	0.0002	0.0001	44.79	0.004479
0.04	17.1	0.0004	0.0002	19.62	0.003924
0.07	17.1	0.0007	0.0003	14.18	0.004254
0.1	17.1	0.001	0.0003	13.27	0.003981
0.2	12.3	0.002	0.001	6.64	0.00664
0.4	8.7	0.004	0.002	3.66	0.00732
0.7	6.5	0.007	0.003	2.47	0.00741
1	5.4	0.01	0.003	2	0.006
2	3.6	0.02	0.01	1.43	0.0143
4	2.4	0.04	0.02	1.09	0.0218
7	1.7	0.07	0.03	0.89	0.0267
10	1.4	0.1	0.03	0.81	0.0243
20	0.88	0.2	0.1	0.71	0.071
100	0	1	0.8	0.56	0.448

$\Rightarrow$ **0.656276**

×0.01
+ = **0.69**
×0.99

This is not much better than 0.69%

TST power control formula used in the simulation:

Equivalent rain path length=7.73 km;
TST transmitting power increase=ccir(p,d) dB;
if (power increase >17.1 dB) power increase =17.1 dB;

where ccir(p,d) is the rain attenuation (CCIR model) in a propagation path length of d km and unavailability p%. ccir(0.1,7.73)=17.1 dB.

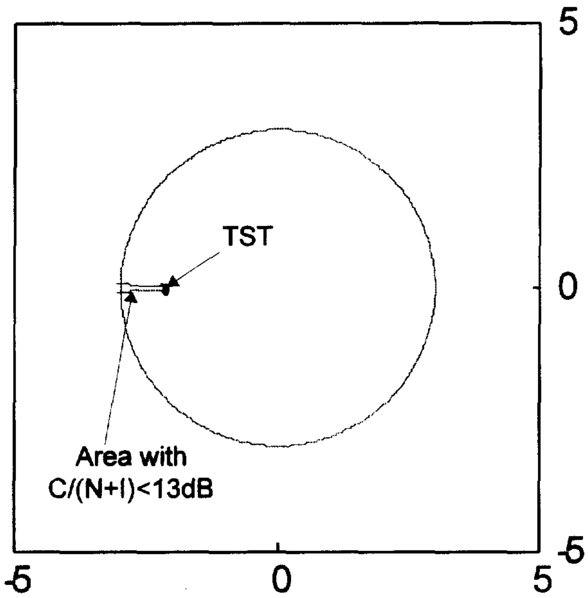

Figure 5-3.
Area within an LMDS cell which experiences significant interference in clear sky condition when TST is located 2.1 miles from cell center.

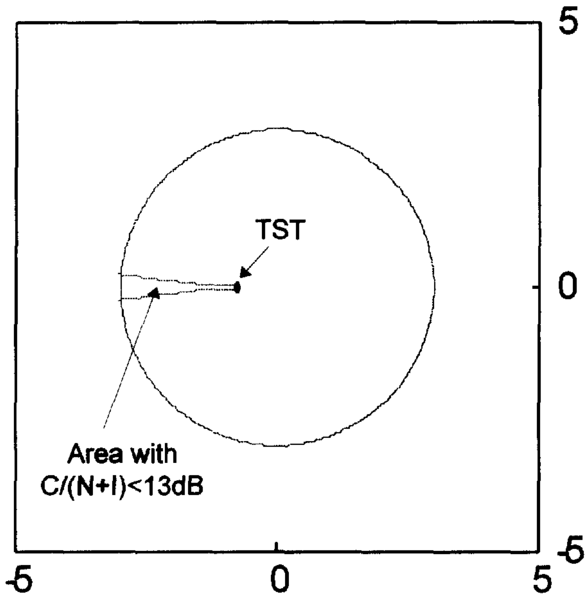

Figure 5-4.
Area within an LMDS cell which experiences significant interference in clear sky condition when TST is located 0.75 miles from cell center.

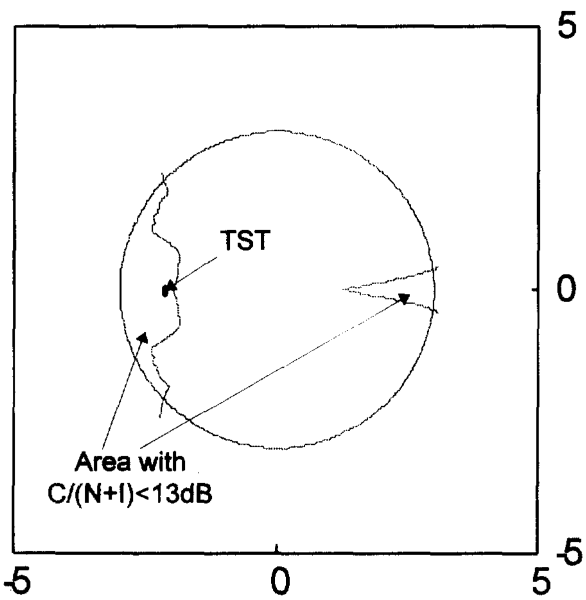

Figure 5-5.
Area within an LMDS cell which experiences significant interference in heavy rain condition when TST is located 2.1 miles from cell center.

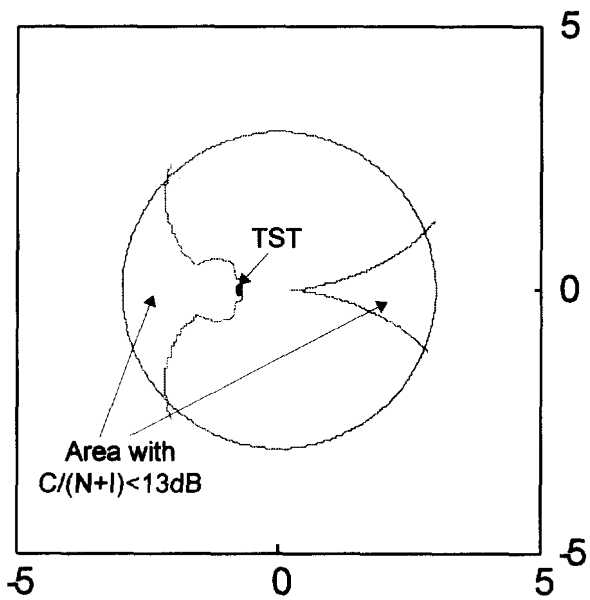

Figure 5-6.
Area within an LMDS cell which experiences significant interference in heavy rain condition when TST is located 0.75 miles from cell center.

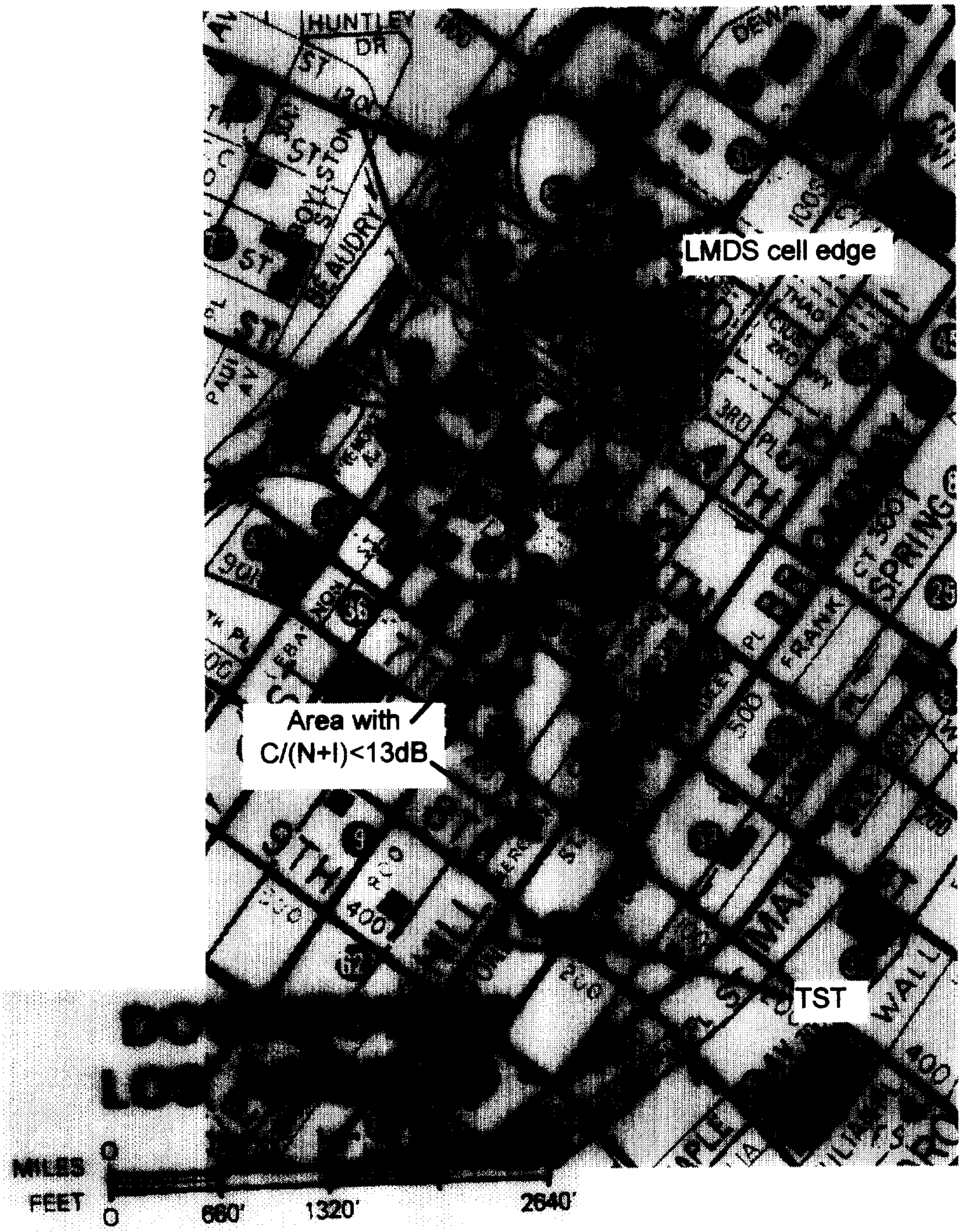

Figure 5-7. Area within an LMDS cell which experiences significant interference in clear sky conditions when TST is located 2.1 miles from cell center.

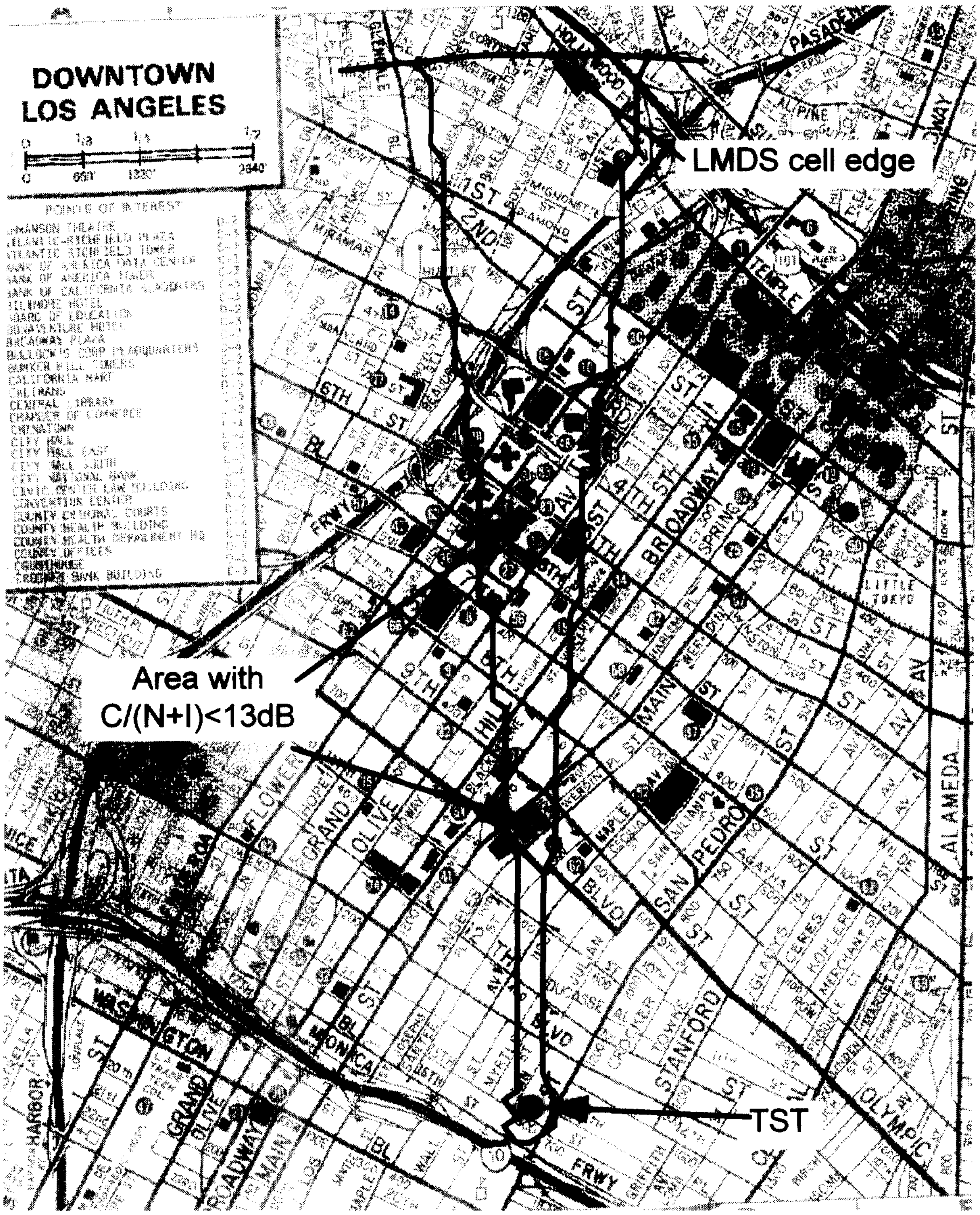

Figure 5-8. Area within an LMDS cell which experiences significant interference in clear sky conditions when TST is located 0.75 miles from cell center.

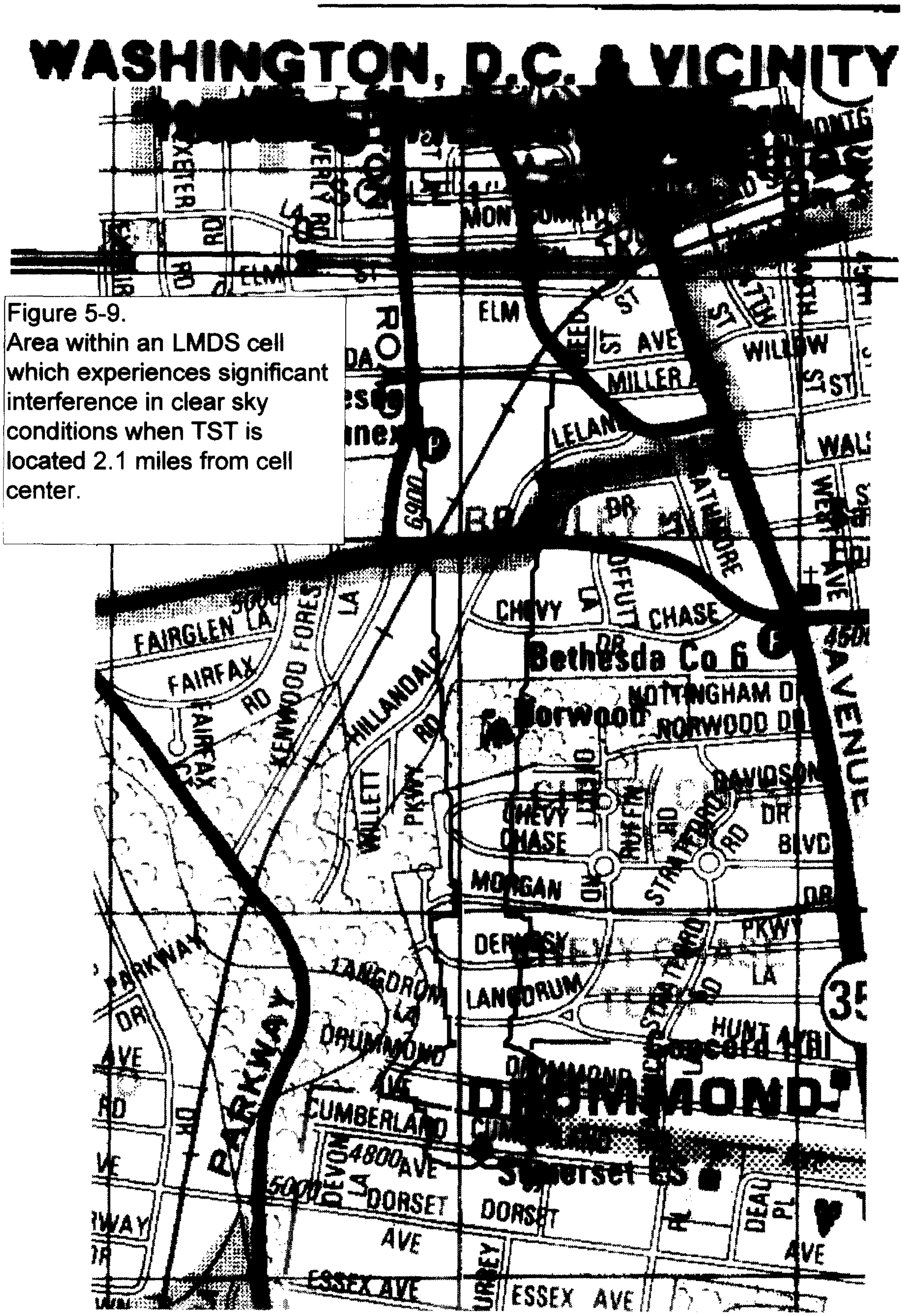

Figure 5-9.
Area within an LMDS cell which experiences significant interference in clear sky conditions when TST is located 2.1 miles from cell center.

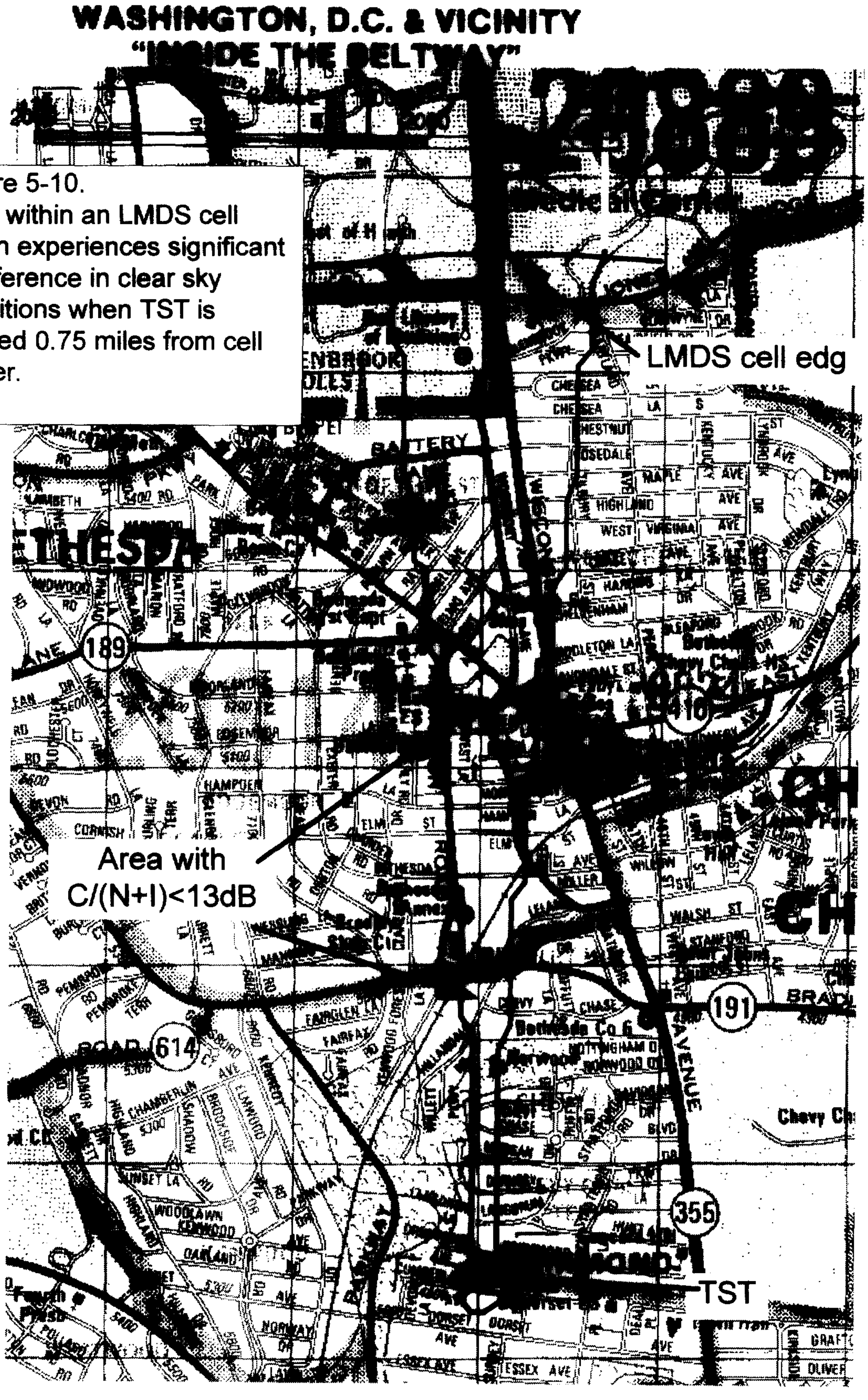

Figure 5-10.
Area within an LMDS cell which experiences significant interference in clear sky conditions when TST is located 0.75 miles from cell center.

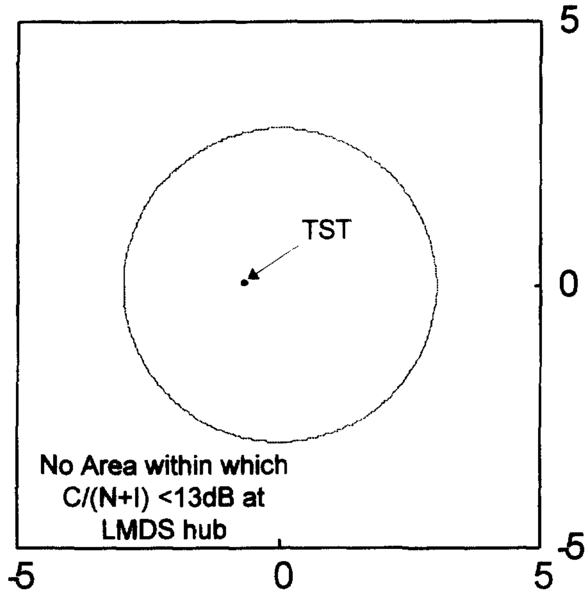

Figure 5-11.
Area within which the return channel will be significantly interfered with when the TST is located 0.75 mile from cell center in clear sky condition.

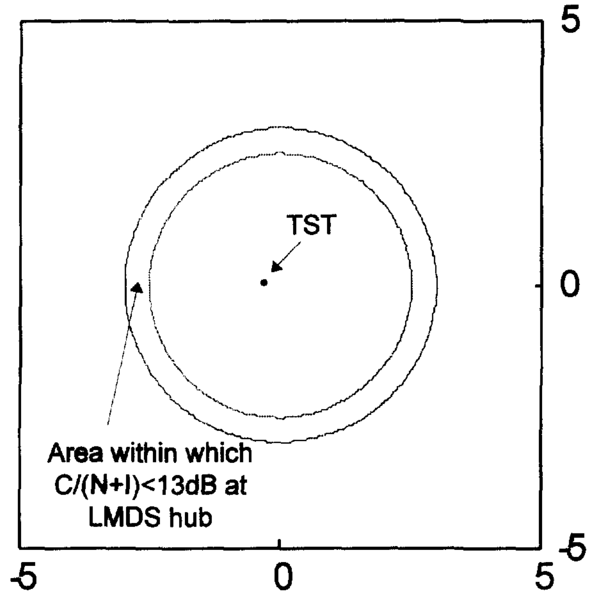

Figure 5-12.
Area within which the return channel will be significantly interfered with when the TST is located 0.3 mile from cell center in clear sky condition.

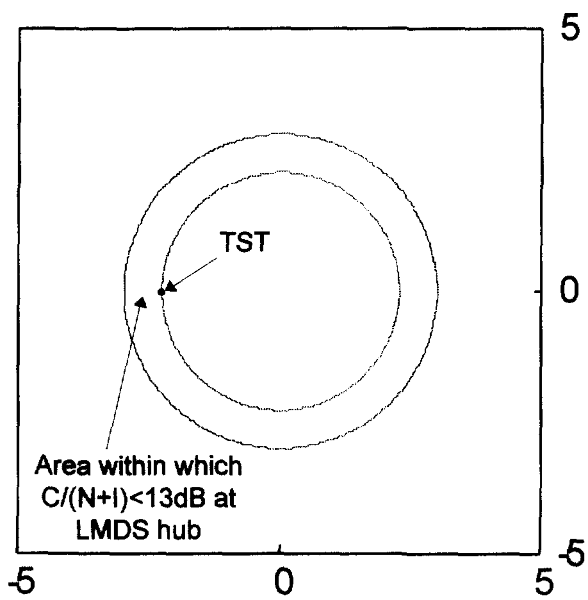

Figure 5-13.
Area within which the return channel will be significantly interfered with when the TST is located 2.1 miles from cell center in heavy rain condition.

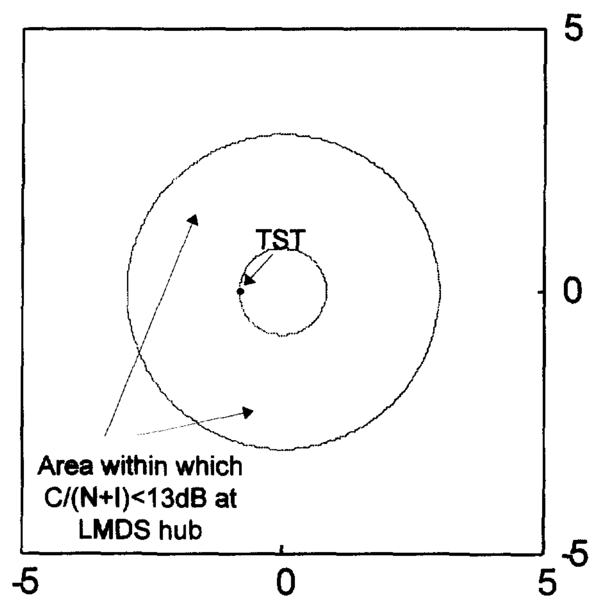

Figure 5-14.
Area within which the return channel will be significantly interfered with when the TST is located 0.75 mile from cell center in heavy rain condition.

AFFIDAVIT OF MIKE YANG

I, Mike Yang, being duly sworn, do depose and state as follows:

1. I am an electrical engineer specializing in Communication Systems Engineering, employed by LinCom Corporation, 5110 W. Goldleaf Circle, Suite 330, Los Angeles, CA 90056. Additional information concerning my engineering background and activities is shown in Attachment A hereto.

2. I prepared with Ali Zahid the Engineering Exhibit which is attached to the foregoing LinCom Corporation report entitled, "Evaluation of Bellcore's Interference Analyses for Co-Frequency Sharing of the 28 GHz Band by the Local Multipoint Distribution Service (LMDS) and the Fixed Satellite Service (FSS)". Except for those factual matters of which official notice may be taken or which are matters of public record, the statements made in the engineering exhibit are true, complete and correct to my personal knowledge.

Date June 9, 1995

Mike Yang
MIKE YANG

Subscribed and sworn before me this 9th day of June, 1995

OFFICIAL SEAL
DELORES F. COUSAR
NOTARY PUBLIC-CALIFORNIA
LOS ANGELES COUNTY
MY COMM. EXP. JUNE 16, 1995

Delores F. Cousar
NOTARY PUBLIC

My commission expires June 16, 1995

The following is a supplement to the affidavit of Mike Yang, 5110 West Goldleaf Circle Suite 330, Los Angeles, CA 90056, Telephone Number (213) 293-3001.

I, Mike Yang, received my BS degree in Electrical Engineering from National Taiwan University, (Taipei, Taiwan) in 1984, my MSEE degree from Unviersity of Southern California, (Los Angeles, California) in 1989.

I have 6 years of experience in the field of commuincations system engineering. From 1989 to the present time, I am a senior systems engineer in the Communication Science Group of LinCom Corporation. I have been working on the projects with NASA GSFC, NASA JSC, Hughes and Teledesic during this period of time.

I have 5 conference papers presented in IEEE MILCOM and GLOBECOM.